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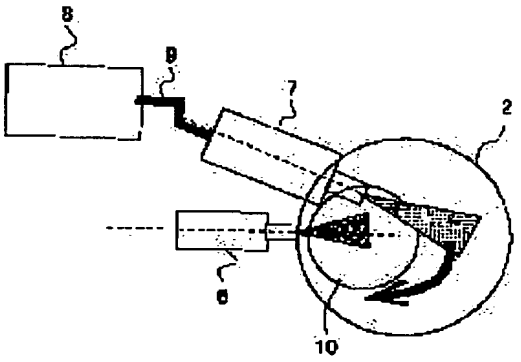
(54) DIRECT INJECTION TYPE SPARK IGNITION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To enhance a combustibility of a stratified charge combustion and a homogeneous combustion by constituting an air-supplying means by an air injection valve for directly injecting an air to a combustion chamber.

SOLUTION: An air supplying means for supplying an air to a combustion chamber in a suction stroke is constituted by an air injection valve 7 for directly supplying a high pressure air to the combustion chamber. By this constitution, when the fuel injection valve 6 injects a fuel in a compression stroke during a stratified charge combustion, the injected fuel is directed to a cavity combustion chamber 10 and a fuel injection valve 6 is exactly mounted on the cavity combustion chamber 10 at a received angle. Whereas, the air injection valve 7 is mounted at an angle such that an air injected in the suction stroke forms, for example, a swirl laterally directed by rotating in a right direction as an arrow and an fuel injected in a compression stroke in which the swirl exists in the cavity combustion chamber 10 is exactly conveyed around an ignition plug. The mounting angle of the air injection valve 7 and the fuel injection valve 6 can intensionally set an interference of the fuel and the air and a granulation and a stratification of the fuel can be carried out.



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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] An air supply means to supply air to a combustion chamber like an inhalation-of-air line, and the fuel injection valve which injects a direct fuel to a combustion chamber, While equipping an ignition plug and a piston crestal plane with a cavity combustion chamber, making a fuel inject in a compression stroke in a low loading region and making stratification combustion perform The injection type spark-ignition engine in a cylinder characterized by constituting said air supply means from an air-injection valve which injects direct air to a combustion chamber in the injection type spark-ignition engine in a cylinder which an inhalation-of-air line makes a fuel inject [spark-ignition engine] to inside in a heavy load region, and was made to make homogeneity combustion perform.
[Claim 2] The injection type spark-ignition engine in a cylinder according to claim 1 characterized by setting it as the include angle which can convey the fuel which arranged the air-injection valve in the fuel injection valve arrangement side, and was injected in whenever [these champing-angles] to a cavity combustion chamber.
[Claim 3] The injection type spark-ignition engine in a cylinder according to claim 2 characterized by setting it as the include angle to which a mutual injection axis crosses and both the injection directions point to whenever [champing-angle / of an air-injection valve and a fuel injection valve] in a cavity combustion chamber.
[Claim 4] The injection type spark-ignition engine in a cylinder given in claims 2 and 3 characterized by arranging two or more air-injection valves.
[Claim 5] The injection type spark-ignition engine in a cylinder according to claim 4 characterized by making air injection perform from one air-injection valve at the time of an idling, having made the sideways revolution style form, making air injection perform from all air-injection valves, and making it make a longitudinal revolution style form at the time of a partial load and a heavy load.
[Claim 6] The injection type spark-ignition engine in a cylinder given in any of claims 1-5 characterized by setting it as multistage at the 1st fuel injection timing which it leaves [fuel injection timing] a part and makes fuel injection timing of the air-injection valve at the time of stratification combustion inject among the predetermined supply air volume like an inhalation-of-air line, and the 2nd fuel injection timing which makes the air contents remaining in the first half of a compression stroke inject they are.
[Claim 7] The injection type spark-ignition engine in a cylinder according to claim 1 characterized by setting it as the include angle with which an air-injection valve is arranged in a fuel injection valve arrangement side, and the blast air and an injection fuel point to whenever [these champing-angles] in a cavity combustion chamber, and the injection direction of the blast air serves as facing down from the injection direction of an injection fuel, and which both the injection axis intersects.
[Claim 8] The injection type spark-ignition engine in a cylinder according to claim 7 characterized by setting it as multistage just before fuel injection at the 1st fuel injection timing which it leaves [fuel injection timing] a part and makes fuel injection timing of the air-injection valve at the time of stratification combustion inject among the predetermined supply air volume like an inhalation-of-air line, and a compression stroke at the 2nd fuel injection timing which makes the remaining air contents inject.
[Claim 9] The injection type spark-ignition engine in a cylinder given in any of claims 1-8 characterized by carrying out injection actuation of the air-injection valve also in an expansion stroke

they are.
[Claim 10] The injection type spark-ignition engine in a cylinder given in any of claims 1-9 characterized by carrying out injection actuation of the air-injection valve even like an exhaust air line they are.
[Claim 11] The injection type spark-ignition engine in a cylinder given in any of claims 1-10 characterized by connecting an inert gas supply path to the air duct of an air-injection valve, and making it make the air which mixed the inert gas of the specified quantity inject they are.
[Claim 12] The injection type spark-ignition engine in a cylinder according to claim 11 characterized by being the exhaust air reflux path where it connects ranging over the air duct and engine flueway of an air-injection valve, and an inert gas supply path introduces a part of exhaust gas.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the injection type spark-ignition engine in a cylinder which injects a direct fuel to a combustion chamber.
[0002]
[Description of the Prior Art] As the injection type spark-ignition engine in a cylinder is shown for example, in JP,9-79079,A, the patent No. 2577019 official report, etc. ** and the exhaust valve which open and close **, an exhaust air port, and ******** and an exhaust air port to the cylinder head, The ignition plug prepared in the location of a combustion chamber facing a core mostly, and the fuel injection valve which an injection nozzle faces a combustion chamber, It arranges, and while injecting a direct fuel to a combustion chamber and making stratification combustion perform from a fuel injection valve at the anaphase of a compression stroke, an inhalation-of-air line makes said fuel injection perform to inside, and he is trying to make homogeneity combustion perform to it in a heavy load region in a low loading region.
[0003]
[Problem(s) to be Solved by the Invention] If a fuel injection valve is arranged in an exhaust valve arrangement side, the thermal effect of a burnt gas will be received greatly, and if it arranges in a combustion chamber core, a thermal effect will be greatly received like the case where it arranges in an exhaust valve arrangement side, From an ignition plug arrangement location shifting from the center of a combustion chamber by central installation of a fuel injection valve, and flame propagation no longer being performed good Since this fuel injection valve is an inlet-valve arrangement side and it is moreover necessary to arrange it in the location near the inlet valve in consideration of the miscibility of a fuel and air, It will become difficult the arrangement location of this fuel injection valve will not only be to restrain, but to take the optimal arrangement layout for stratification combustion and homogeneity combustion in response to constraint to whenever [champing-angle] according to the structure of the circumference of a suction port.
[0004] Especially this will be increasingly remarkable in the engine concept by which ** and an exhaust valve many became petaloid.
[0005] Moreover, in order to make closing motion control of an inlet valve perform inhalation of air from a suction port apart from the problem on arrangement of such a fuel injection valve, It is important to make the fuel which could not deny the fall of the CV value by the pumping loss or friction loss of a valve gear system, but was especially injected in the compression stroke by the injection type spark-ignition engine in a cylinder at the time of stratification combustion convey to the circumference of the ignition plug of the center of a combustion chamber certainly. For this reason, since it is necessary to add the variant for making a suction port generate a longitudinal direction revolution style (swirl) and a lengthwise direction revolution style (tumble flow), an above-mentioned pumping loss and friction loss will increase further.
[0006] Furthermore, although the fuel injected by the compression stroke as mentioned above at the time of stratification combustion is put in the style of [of new mind] revolution and is made to convey to the circumference of an ignition plug Even if a revolution style is formed by the revolution grant means of a suction port, the new mind inhaled from a suction port like an inhalation-of-air line In order to have to decrease this revolution style at fuel injection timing, to have to inject a fuel to

this decreased revolution style and to have to make transportation and combustion of a fuel perform, Matching of inhalation-of-air control and fuel-injection control is difficult, and moreover, since a gas flow becomes weaker, the improvement in stratification combustion is not greatly expectable.
[0007] Then, while this invention can expand the degree of freedom of the arrangement layout of a fuel injection valve, the injection type spark-ignition engine in a cylinder not only whose stratification combustion but also the flammability of homogeneity combustion can set up inhalation-of-air timing appropriately, and can be made to be able to generate a strong gas flow, and can improve much more is offered.
[0008]
[Means for Solving the Problem] An air supply means to supply air to a combustion chamber like an inhalation-of-air line if it is in invention of claim 1, While equipping with a cavity combustion chamber the fuel injection valve which injects a direct fuel to a combustion chamber, an ignition plug, and a piston crestal plane, making a fuel inject in a compression stroke in a low loading region and making stratification combustion perform In the injection type spark-ignition engine in a cylinder which an inhalation-of-air line makes a fuel inject [spark-ignition engine] to inside in a heavy load region, and was made to make homogeneity combustion perform, it is characterized by constituting said air supply means from an air-injection valve which injects direct air to a combustion chamber.
[0009] If it is in invention of claim 2, it is characterized by setting it as the include angle which can convey the fuel which arranged the air-injection valve according to claim 1 in the fuel injection valve arrangement side, and was injected in whenever [these champing-angles] to a cavity combustion chamber.
[0010] If it is in invention of claim 3, it is characterized by setting it as the include angle to which a mutual injection axis crosses and both the injection directions point to whenever [champing-angle / of an air-injection valve and a fuel injection valve according to claim 2] in a cavity combustion chamber.
[0011] If it is in invention of claim 4, it is characterized by arranging two or more air-injection valves of a publication in claims 2 and 3.
[0012] If it is in invention of claim 5, the air-injection valve according to claim 4 is characterized by making air injection perform from one air-injection valve at the time of an idling, having made the sideways revolution style form, making air injection perform from all air-injection valves, and making it make a longitudinal revolution style form at the time of a partial load and a heavy load.
[0013] If it is in invention of claim 6, it is characterized by setting it as multistage at the 1st fuel injection timing which it leaves [fuel injection timing] a part and makes fuel injection timing of the air-injection valve at the time of stratification combustion according to claim 1 to 5 inject among the predetermined supply air volume like an inhalation-of-air line, and the 2nd fuel injection timing which makes the air contents remaining in the first half of a compression stroke inject.
[0014] If it is in invention of claim 7, it is characterized by setting it as the include angle with which an air-injection valve according to claim 1 is arranged in a fuel injection valve arrangement side, and the blast air and an injection fuel point to whenever [these champing-angles] in a cavity combustion chamber, and the injection direction of the blast air serves as facing down from the injection direction of an injection fuel and which both the injection axis intersects.
[0015] If it is in invention of claim 8, it is characterized by setting it as multistage just before fuel injection at the 1st fuel injection timing which it leaves [fuel injection timing] a part and makes fuel injection timing of the air-injection valve at the time of stratification combustion according to claim 7 inject among the predetermined supply air volume like an inhalation-of-air line, and a compression stroke at the 2nd fuel injection timing which makes the remaining air contents inject.
[0016] If it is in invention of claim 9, it is characterized by carrying out injection actuation of the air-injection valve according to claim 1 to 8 also in an expansion stroke.
[0017] If it is in invention of claim 10, it is characterized by carrying out injection actuation of the air-injection valve according to claim 1 to 9 even like an exhaust air line.
[0018] If it is in invention of claim 11, it is characterized by connecting an inert gas supply path to the air duct of an air-injection valve according to claim 1 to 10, and making it make the air which mixed the inert gas of the specified quantity inject.

[0019] If it is in invention of claim 12, it connects ranging over the air duct and engine flueway of an air-injection valve, and the inert gas supply path according to claim 11 is characterized by being the exhaust air reflux path which introduces a part of exhaust gas.
[0020]
[Effect of the Invention] Since according to invention according to claim 1 the air supply means was constituted from an air-injection valve which injects direct air to a combustion chamber and the suction port and the inlet valve are abolished, a fuel injection valve can be attached in the location and include angle from which the optimal direction of fuel injection is acquired, without being restrained by these suction ports and the inlet valve.
[0021] Moreover, there is no friction loss of an inlet valve and its valve gear system, and it combines with moreover an inlet valve and the pumping loss by the ventilation resistance of a suction port being lost, and since the high-pressure air injected like the inhalation-of-air line acts in the depression direction of a piston, the reduction effectiveness of a pumping loss is large and can raise a CV value.
[0022] Furthermore, while being able to make the fuel transportation to the circumference of the ignition plug at the time of stratification combustion perform good, without using a revolution style grant means since a strong gas flow can be formed by high-pressure air injection, interference with a fuel and air can be set up intentionally, and atomization of a fuel and stratification-ization can be performed easily, therefore the flammability of stratification combustion and homogeneity combustion can be improved.
[0023] Moreover, since it is not necessary to regard interference with the fuel and inlet valve which were injected from the fuel injection valve on the occasion of the inhalation-of-air line of a fuel making it inject and a fuel spray angle can be set up the optimal, not only homogeneity combustion but also the flammability of stratification combustion can improve further.
[0024] According to invention according to claim 2, since it is set as the optimal include angle which can convey the fuel injected at the time of stratification combustion to a cavity combustion chamber, without receiving constraint according an air-injection valve to a suction port and an inlet valve in addition to the effect of the invention of claim 1, the shelf life of a gas flow can improve the transportability to the circumference of the ignition plug of a fuel highly, and can improve the flammability of stratification combustion further.
[0025] Since the air-injection axis and the fuel-injection axis cross in addition to the effect of the invention of claim 2, while the inhalation-of-air line of a fuel can perform atomization of a fuel at the time of injection according to invention according to claim 3 Since improvement in the output in the heavy load region which performs homogeneity combustion as which a real charging efficiency is raised and high power is required since air temperature can be energetically lowered for latent heat of vaporization from the blast air can be realized and the blast air moreover directs in a cavity combustion chamber, It can control that a fuel adheres to a cavity combustion chamber, and smoked generating and generating unburnt [HC] can be reduced to it.
[0026] According to invention according to claim 4, since two or more air-injection valves are arranged in addition to the effect of the invention of claims 2 and 3, when one air-injection valve of the amount of air supply is insufficient, or when more air needs like supercharge, it can respond appropriately.
[0027] According to invention according to claim 5, to the effect of the invention of claim 4 In addition, in order to make air injection perform from one air-injection valve at the time of an idling and to make a sideways revolution style (swirl) form, Also in the time of little idling of supply air volume, a swirl can be certainly formed in a cavity combustion chamber, and stabilization of combustion can be attained. On the other hand, in order to make air injection perform from all air-injection valves at the time of a partial load and a heavy load and to make a longitudinal revolution style (a tumble flow, reverse tumble flow) form, Fuel adhesion in a cavity combustion chamber can be controlled, a smoke and generating unburnt [HC] can be reduced, and stabilization of homogeneity combustion and stratification combustion and improvement in an output can be realized.
[0028] According to invention according to claim 6, since air injection is made to perform the first half of a compression stroke also at the time of stratification combustion in addition to the effect of

the invention of claims 1-5, a gas flow is strengthened, the transportability of the fuel to the circumference of an ignition plug is raised, and stratification combustion can be stabilized further.
[0029] According to invention according to claim 7, to the effect of the invention of claim 1 In addition, since both the blast air and an injection fuel direct in a cavity combustion chamber and the blast air is injected downward rather than an injection fuel, In order to be able to form the film of air in a cavity combustion chamber as early flow and to make a fuel inject on it, fuel adhesion in a cavity combustion chamber can be avoided at the time of stratification combustion, and it can attain stabilization of stratification combustion, and a smoke and reduction-izing unburnt [HC].
[0030] Moreover, by the ability attaining stabilization of homogeneity combustion, since atomization of a fuel can be performed while being able to perform positively mixing with the blast air and an injection fuel, and stirring at the time of homogeneity combustion, since the high-pressure blast air blows on a cavity combustion chamber and it is moreover hit, fuel adhesion in this cavity combustion chamber can be avoided, and a smoke and reduction-ization unburnt [HC] can be attained.
[0031] Since air injection is made to perform also just before fuel injection by the compression stroke at the time of stratification combustion in addition to the effect of the invention of claim 7, while according to invention according to claim 8 strengthening the film of the air formed in a cavity combustion chamber and being able to prevent fuel adhesion more certainly, a gas flow can be strengthened and the transportability of the fuel to the circumference of an ignition plug can be raised.
[0032] According to invention according to claim 9, since the air injection from an air-injection valve is made to perform also in an expansion stroke in addition to the effect of the invention of claims 1-8, while activating combustion unburnt [HC] and being able to improve thermal efficiency, a smoke and the cure against reduction-ized unburnt [HC] can be put into practice.
[0033] According to invention according to claim 10, in addition to the effect of the invention of claims 1-9, since the air injection from an air-injection valve is made to perform even like an exhaust air line, scavenging efficiency can be raised.
[0034] It is NOx in order to make the air which mixed inert gas inject from an air-injection valve in addition to the effect of the invention of claims 1-10 according to invention according to claim 11. The reduction effectiveness can be acquired.
[0035] In order to use [according to invention according to claim 12] a burnt gas effectively as inert gas in addition to the effect of the invention of claim 11, it is NOx advantageously in cost by exhaust air reflux. The reduction effectiveness can be acquired.
[0036]
[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained in full detail with a drawing.
[0037] In drawing 1 and 2, as for a cylinder block and 2, 1 shows the combustion chamber in which a piston and 3 were formed in by the cylinder head, and 4 was formed by these cylinder blocks 1, the piston 2, and the cylinder head 3.
[0038] While having arranged the ignition plug 5 in the location of a combustion chamber 4 which faces in the center mostly at the cylinder head 3, the fuel injection valve 6 which injects a fuel to the direct combustion chamber 4 is arranged in the flank of the opposite side the arrangement side of the exhaust valve outside drawing.
[0039] Unlike the usual engine, a suction port and an inlet valve are not in this cylinder head 3, and the air-injection valve 7 which injects the high-pressure air which is compressed with high pressure pumping 8 and sent to the arrangement side of said fuel injection valve 6 by the air duct 9 to the direct combustion chamber 4 is arranged.
[0040] The cavity combustion chamber 10 which receives the fuel injected from the fuel injection valve 6 in the compression stroke at the time of stratification combustion is formed in ****** which ****(ed) to the side which arranged said fuel injection valve 6 at the crestal plane of a piston 2.
[0041] When a fuel is injected in a compression stroke at the time of stratification combustion, while having attached this injection fuel at the include angle which directs in the cavity combustion chamber 4 and is certainly received by this cavity combustion chamber 4, a fuel injection valve 6 The air-injection valve 7 rotates clockwise, as the air injected like the inhalation-of-air line shows

drawing 2 by the arrow head, and a sideways revolution style (swirl) is formed. It has attached at the include angle which can convey certainly the fuel which this swirl was saved in the cavity combustion chamber 10 by the compression stroke, and was injected in this compression stroke to the circumference of an ignition plug 5.

[0042] Drawing 3 shows each fuel injection timing of the air-injection valve 7 at the time of the stratification combustion in a four-cycle stroke, and a fuel injection valve 6, and the ignition timing of an ignition plug 5, and drawing 4 shows each fuel injection timing of these air-injection valve 7 at the time of homogeneity combustion, and a fuel injection valve 6, and the ignition timing of an ignition plug 5, in A, F shows fuel injection timing of a fuel and S shows ignition timing for fuel injection timing of air, respectively.

[0043] Therefore, since according to the configuration of this 1st operation gestalt an air supply means to supply air to a combustion chamber 4 like an inhalation-of-air line was constituted from an air-injection valve 7 which supplies direct high-pressure air to this combustion chamber 4 and the suction port and the inlet valve are abolished, a fuel injection valve 6 can be attached in the location and include angle from which the optimal direction of fuel injection is acquired, without receiving constraint in these suction ports or an inlet valve.

[0044] Moreover, there is no friction loss of an inlet valve and its valve gear system, and it combines with moreover an inlet valve and the pumping loss by the ventilation resistance of a suction port being lost, and since the high-pressure air injected like the inhalation-of-air line acts in the depression direction of a piston 2, the reduction effectiveness of a pumping loss is large and can raise a CV value.

[0045] Furthermore, since it can attach at the optimal include angle which can form a swirl, without being able to form a strong gas flow by high-pressure air injection, and receiving constraint according the air-injection valve 7 to a suction port or an inlet valve, The shelf life of a gas flow can be raised without using a revolution style grant means. Therefore, the transportability of the fuel to the circumference of an ignition plug 5 is raised at the time of stratification combustion. Moreover, since interference with a fuel and air can also be set up intentionally and atomization of a fuel and stratification-ization can be performed easily, whenever [champing-angle / of the air-injection valve 7 and a fuel injection valve 6] can improve the flammability of stratification combustion and homogeneity combustion.

[0046] Moreover, since it is not necessary to regard interference with the fuel and inlet valve which were injected from the fuel injection valve 6 on the occasion of the inhalation-of-air line of a fuel making it inject and a fuel spray angle can be set up the optimal, not only homogeneity combustion but also the flammability of stratification combustion can improve further.

[0047] In the configuration of the 1st operation gestalt shown in said drawing 1 and 2 if drawing 5 shows the 2nd operation gestalt of this invention and was in this operation gestalt The 1st fuel injection timing A1 which it leaves [fuel injection timing] a part and makes fuel injection timing of the above-mentioned air-injection valve 7 at the time of stratification combustion inject among the predetermined supply air volume like an inhalation-of-air line The 2nd fuel injection timing A2 which makes the air contents remaining in the first half of a compression stroke inject It is set as multistage.

[0048] Therefore, according to the configuration of this 2nd operation gestalt, since air injection is made to perform the first half of a compression stroke also at the time of stratification combustion in addition to the effectiveness of said 1st operation gestalt, a swirl can be strengthened, the transportability of the fuel to the circumference of an ignition plug 5 can be raised, and stratification combustion can be stabilized further.

[0049] The 3rd operation gestalt of this invention is shown, if it is in this operation gestalt, injection actuation of the air-injection valve 7 is carried out in an expansion stroke also at the time of which operational status at the time of stratification combustion and homogeneity combustion (drawing 6) (drawing 7), and drawing 6 and 7 are the injection Aalpha1 of the additional air of requirements. He is trying to make it carry out.

[0050] Therefore, according to the configuration of this 3rd operation gestalt, in addition to the effectiveness of said 1st operation gestalt and the 2nd operation gestalt, it is the air injection Aalpha1 of requirements by the air-injection valve 7 under the temperature conditions that combustion

temperature is high, also in an expansion stroke. Since it is make to carry out, while activating combustion unburnt [HC] and being able to improve thermal efficiency with this additional air, a smoke and the cure against reduction-ized unburnt [HC] can be put into practice.
[0051] It is the injection Aalpha2 of additional air even like an exhaust air line like [although additional air is made to inject in an expansion stroke in said 3rd operation gestalt] drawing 8 and the 4th operation gestalt shown in 9. Scavenging efficiency can be raised if it is made to carry out.
[0052] Moreover, injection Aalpha2 of the additional air like this exhaust-air line If it is made to carry out in the first half like the exhaust air line by which a high combustion temperature is maintained as the chain line shows, it will be the injection Aalpha1 of additional air in an expansion stroke. Activation of combustion unburnt [HC] can be expected like the case where it carries out, and combustion activation of the cylinder liner which fails to be especially scratched by rise of a piston like this exhaust air line adhesion unburnt [HC] can also be planned.
[0053] If drawing 10 and 11 show the 5th operation gestalt of this invention and are in this operation gestalt, both the injection axis has set whenever [champing-angle / of the air-injection valve 7 and a fuel injection valve 6] as the vertical direction and the include angle to which are horizontal, and cross and both the injection directions point in the cavity combustion chamber 10.
[0054] Therefore, since the air-injection axis and the fuel-injection axis cross, while according to the configuration of this 5th operation gestalt the same effectiveness as said 1st operation gestalt is acquired, and also the inhalation-of-air line of a fuel can perform atomization of a fuel at the time of injection Since air temperature can be energetically lowered for latent heat of vaporization from the blast air, improvement in the output in the heavy load region which performs homogeneity combustion as which a real charging efficiency is raised and high power is required is realizable.
[0055] And since the blast air directs in the cavity combustion chamber 10, it can control that a fuel adheres to the cavity combustion chamber 10, and a smoke and generating unburnt [HC] can be reduced to it.
[0056] The 1st fuel injection timing A1 which sets in this 5th operation gestalt and can be set like an inhalation-of-air line here like the 2nd operation gestalt which showed fuel injection timing at the time of stratification combustion of the air-injection valve 7 to drawing 5 , The 2nd fuel injection timing A2 in the first half of a compression stroke If it is set as multistage This 2nd fuel injection timing A2 The air injected by the cavity combustion chamber 10 becomes possible [becoming the swirl which fully had inertia in this cavity combustion chamber 10, and conveying a fuel certainly by the circumference of an ignition plug 5], and can raise the stability of stratification combustion further.
[0057] moreover -- since a fuel can already spout and - ****** can also be realized -- gaseous mixture -- formation -- good -- and NOx The reduction effectiveness is acquired, and moreover, since the heat release stage of combustion is overdue, thermal efficiency can also be raised.
[0058] If drawing 12 and 13 show the 6th operation gestalt of this invention and are in this operation gestalt, in the air-injection valve 7, specifically they are the arrangement side of a fuel injection valve 6, carry out plane view of two or more two air-injection valves 7 and 7, and have attached them in the inner sense mostly focusing on the injection axis of this fuel injection valve 6 at axial symmetry.
[0059] Moreover, these two air-injection valves 7 and 7 are arranged by whenever [champing-angle / which can form the so-called longitudinal revolution style of the order tumble which flows toward the crestal plane of a piston 2 through the ignition plug 5 bottom from the exhaust valve side outside drawing], as the blast air shows by the arrow head of drawing 12 .
[0060] Therefore, according to the configuration of this 6th operation gestalt, the same effectiveness as said 1st operation gestalt is acquired, and also since two air-injection valves 7 and 7 are arranged, when one air-injection valve 7 of the amount of air supply is insufficient, or when more air needs like supercharge, it can respond appropriately.
[0061] Moreover, if make air injection perform only from one air-injection valve 7 at the time of an idling, and make a swirl form, air injection is made to perform to coincidence from both the air-injection valves 7 and 7 at the time of a partial load and a heavy load and it is made to make an order tumble flow form Also in the time of little idling of supply air volume, a swirl can be certainly formed in the cavity combustion chamber 10, and stabilization of combustion can be attained. On the other hand, since fuel adhesion in the cavity combustion chamber 10 is controlled by the order

tumble flow at the time of a partial load and a heavy load and a smoke and generating unburnt [HC] can be reduced, stabilization of homogeneity combustion and stratification combustion and improvement in an output are realizable.

[0062] Furthermore, the 1st fuel injection timing A1 which can set fuel injection timing of two air-injection valves 7 and 7 at the time of stratification combustion like an inhalation-of-air line like the 2nd operation gestalt which showed drawing 5 also in this 6th operation gestalt The 2nd fuel injection timing A2 in the first half of a compression stroke By setting it as multistage, an order tumble flow can be strengthened and the transportability of the fuel to the circumference of an ignition plug 5 can be raised.

[0063] In addition, although he is trying to make an order tumble flow form with this operation gestalt, it is also possible to make whenever [champing-angle / of the air-injection valves 7 and 7] into longitude so that a reverse tumble flow can be formed.

[0064] It arranges in a right above location mostly. if drawing 14 and 15 show the 7th operation gestalt of this invention and are in this operation gestalt -- the air-injection valve 7 -- a fuel injection valve 6 -- The blast air and an injection fuel point to whenever [champing-angle / of these air-injection valve 7 and a fuel injection valve 6] in the cavity combustion chamber 10. And the injection direction of the blast air serves as facing down from the injection direction of an injection fuel, and it is set as the include angle to which a mutual injection axis crosses in the vertical direction. It is made to be formed in the so-called reverse tumble flow to which the blast air crosses the front end part of a fuel injection valve 6 as the arrow head of drawing 14 shows, it is reversed toward the cavity combustion chamber 10 in this cavity combustion chamber 10, and flows toward an ignition plug 5.

[0065] Therefore, according to the configuration of this 7th operation gestalt, the same effectiveness as said 1st operation gestalt is acquired, and also Since both the blast air and an injection fuel direct in the cavity combustion chamber 10, and the blast air is injected downward rather than an injection fuel and a reverse tumble flow is formed, In order to be able to form the film of air in the cavity combustion chamber 10 as early flow and to make a fuel inject on it, fuel adhesion in the cavity combustion chamber 10 can be avoided at the time of stratification combustion, and it can attain stabilization of stratification combustion, and a smoke and reduction-izing unburnt [HC].

[0066] Moreover, by the ability attaining stabilization of homogeneity combustion, since atomization of a fuel can be performed while being able to perform positively mixing with the blast air and an injection fuel, and stirring at the time of homogeneity combustion, since the high-pressure blast air blows on the cavity combustion chamber 10 and it is moreover hit, fuel adhesion in this cavity combustion chamber 10 can be avoided, and a smoke and reduction-ization unburnt [HC] can be attained.

[0067] Furthermore, since an injection fuel can lower air temperature for latent heat of vaporization energetically from the blast air at the time of the homogeneity combustion to which the inhalation-of-air line of this fuel injects like said drawing 10 and the 5th operation gestalt shown in 11, a real charging efficiency is raised and high power can be obtained.

[0068] In the structure of the 7th operation gestalt shown in said drawing 14 and 15 if drawing 16 shows the 8th operation gestalt of this invention and was in this operation gestalt The 1st fuel injection timing A1 which it leaves [fuel injection timing] a part and makes fuel injection timing of the above-mentioned air-injection valve 7 at the time of stratification combustion inject among the predetermined supply air volume like an inhalation-of-air line It is set as the 2nd fuel injection timing which makes the remaining air contents inject just before the fuel injection timing F of a compression stroke anaphase.

[0069] Therefore, since air injection is made to perform also just before fuel injection by the compression stroke at the time of stratification combustion according to the configuration of this 8th operation gestalt, while strengthening the film of the air formed in the cavity combustion chamber 10 and being able to prevent fuel adhesion more certainly, a reverse tumble flow can be strengthened and the transportability of the fuel to the circumference of an ignition plug 5 can be raised.

[0070] In addition, in each operation gestalt shown in drawing 10 -16, the reduction effectiveness unburnt [HC] and improvement in scavenging efficiency can be aimed at an expansion stroke and by reaching, or carrying out injection actuation of the air-injection valve 7, and making additional air

inject even like an exhaust air line like drawing 6 , 7 or drawing 8 , and the operation gestalt shown in 9.

[0071] Drawing 17 shows the 9th operation gestalt of this invention, and is NOx at this operation gestalt. It has been made to carry out injection supply of the air which mixed inert gas from the air-injection valve 7 in the combustion chamber 4 for the cure against reduction.

[0072] The case where it applies to the engine concept of the 1st operation gestalt shown in drawing 1 for convenience by drawing 17 is shown. With this operation gestalt, a mixer room 11 is formed in the middle of the air duct 9 of the air-injection valve 7. The exhaust air reflux path 13 is connected ranging over this mixer room 11 and the exhaust air port 12. Perform reflux exhaust air (EGR) of the proper amount according to inspired air volume as inert gas to the bottom of control by the exhaust air reflux control valve equipment 14 infixed in this exhaust air reflux path 13, and make it mix with new mind in a mixer room 11, Exterior EGR is made to perform, and it is NOx. He is trying to acquire the reduction effectiveness. In addition, 15 show an exhaust valve among drawing 17 .

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The cross-section explanatory view showing the configuration of the 1st operation gestalt of this invention roughly.
[Drawing 2] The rough flat-surface explanatory view of the 1st operation gestalt of this invention.
[Drawing 3] The explanatory view showing the air-injection stage at the time of stratification combustion of the 1st operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 4] The explanatory view showing the air-injection stage at the time of homogeneity combustion of the 1st operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 5] The explanatory view showing the air-injection stage at the time of stratification combustion of the 2nd operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 6] The explanatory view showing the air-injection stage at the time of stratification combustion of the 3rd operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 7] The explanatory view showing the air-injection stage at the time of homogeneity combustion of the 3rd operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 8] The explanatory view showing the air-injection stage at the time of stratification combustion of the 4th operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 9] The explanatory view showing the air-injection stage at the time of homogeneity combustion of the 4th operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 10] The cross-section explanatory view showing the configuration of the 5th operation gestalt of this invention roughly.
[Drawing 11] The rough flat-surface explanatory view of the 5th operation gestalt of this invention.
[Drawing 12] The cross-section explanatory view showing the configuration of the 6th operation gestalt of this invention roughly.
[Drawing 13] The rough flat-surface explanatory view of the 6th operation gestalt of this invention.
[Drawing 14] The cross-section explanatory view showing the configuration of the 7th operation gestalt of this invention roughly.
[Drawing 15] The rough flat-surface explanatory view of the 7th operation gestalt of this invention.
[Drawing 16] The explanatory view showing the air-injection stage at the time of stratification combustion of the 8th operation gestalt of this invention, fuel injection timing, and ignition timing.
[Drawing 17] The cross-section explanatory view showing the configuration of the 9th operation gestalt of this invention roughly.
[Description of Notations]
1 Cylinder Block
2 Piston
3 Cylinder Head
4 Combustion Chamber
5 Ignition Plug
6 Fuel Injection Valve
7 Air-Injection Valve
9 Air Duct
10 Cavity Combustion Chamber
12 Exhaust Air Port (Flueway)

13 Exhaust Air Reflux Path (Inert Gas Supply Path)

[Translation done.]

* NOTICES *

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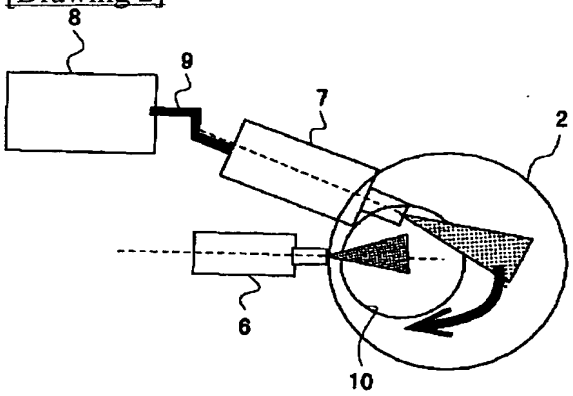
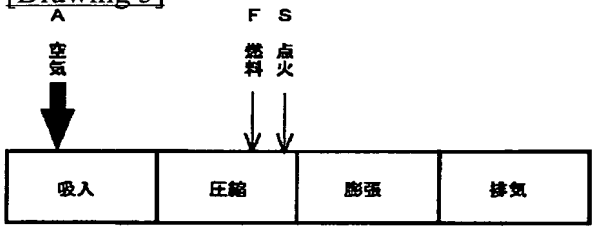
DRAWINGS

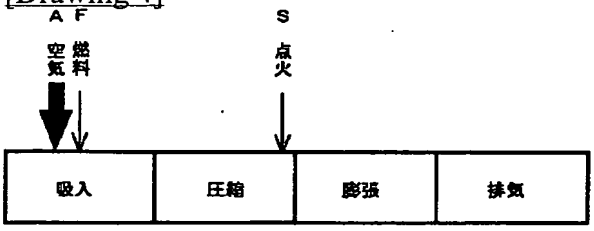
[Drawing 2]



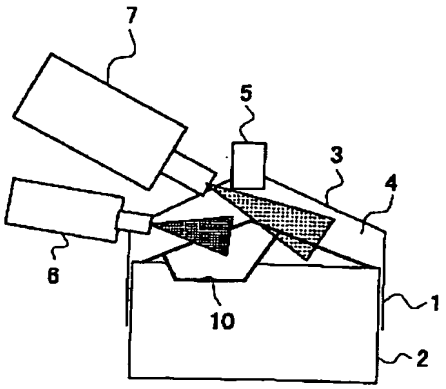
[Drawing 3]



[Drawing 4]

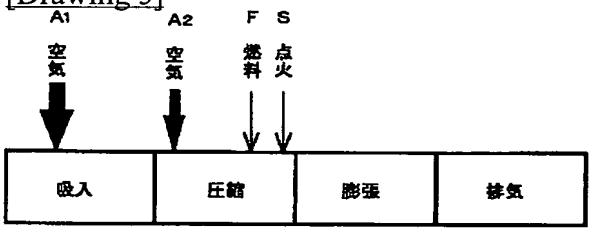


[Drawing 1]



1…シリンダブロック
2…ピストン
3…シリンダヘッド
4…燃焼室
5…点火プラグ
6…燃料噴射弁
7…空気噴射弁
9…空気通路
10…キャビティ燃焼室
12…排気ポート（排気通路）
13…排気環流通路（不活性ガス供給通路）

[Drawing 5]



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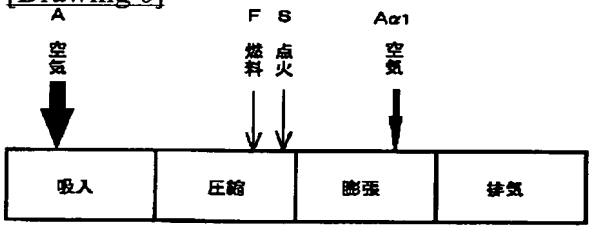

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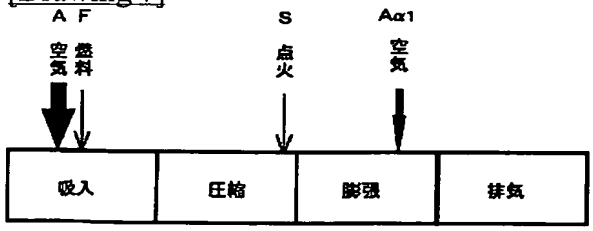

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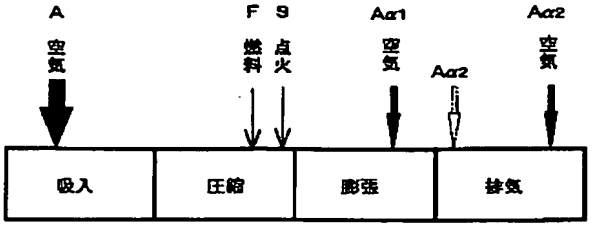

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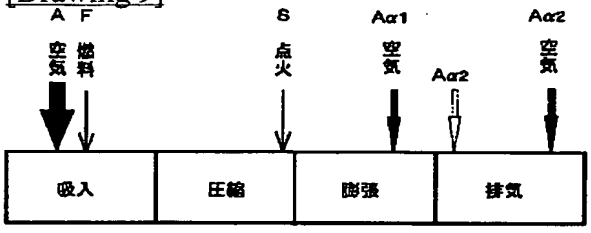

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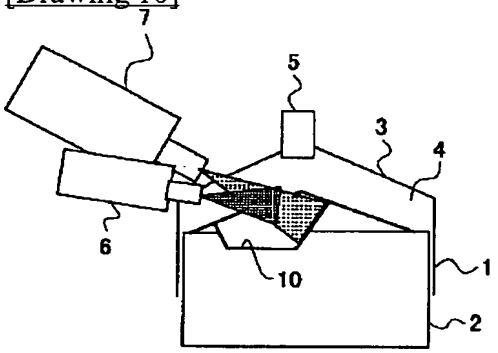
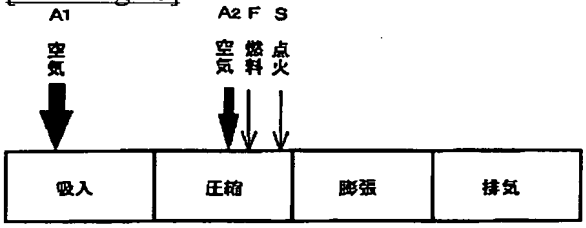


[Drawing 16]



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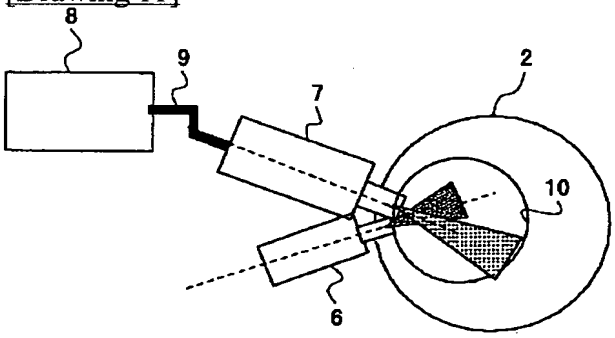

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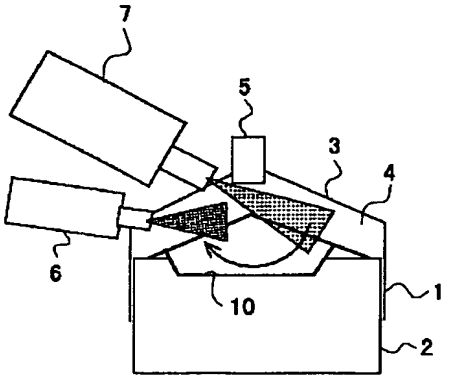
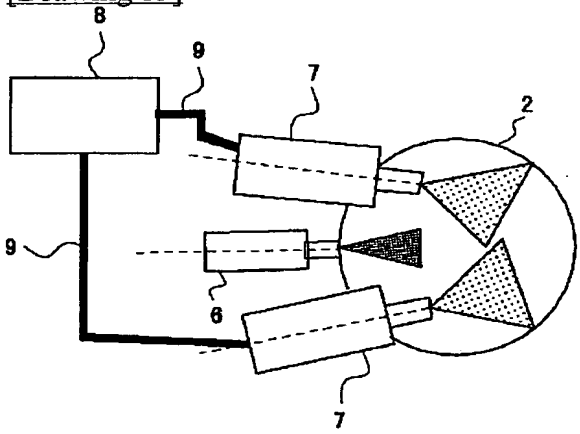


[Drawing 13]



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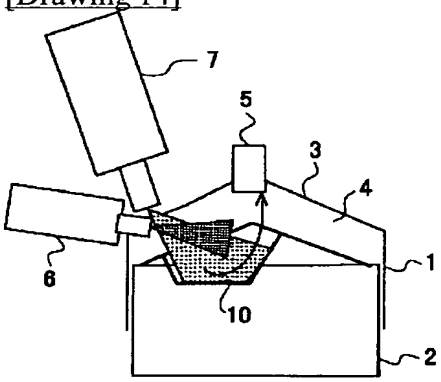

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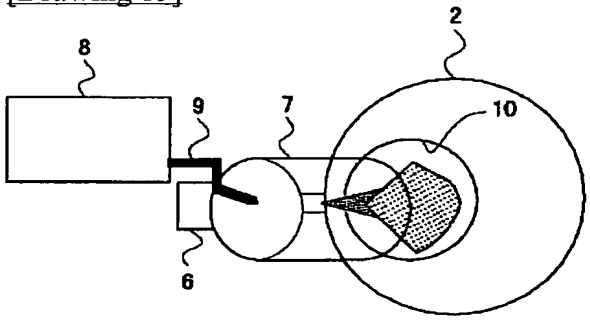
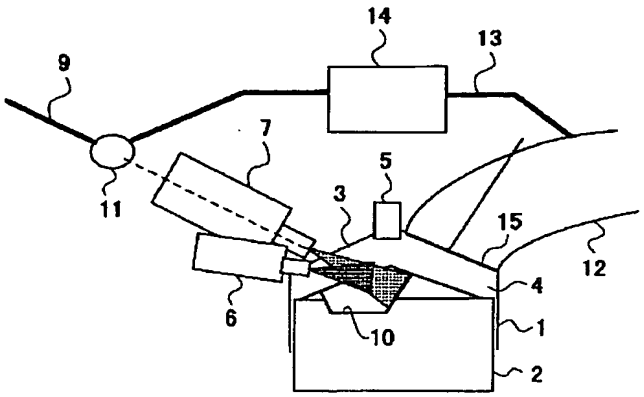


[Drawing 17]



[Translation done.]

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17/00		17/00	F	3G301
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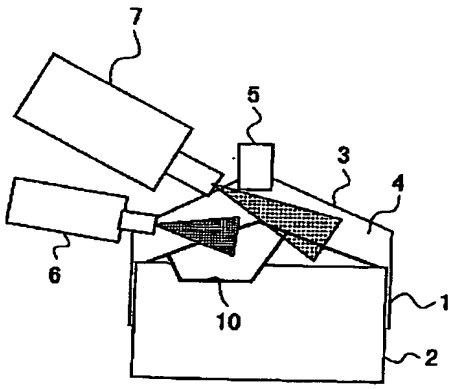
(54)【発明の名称】筒内噴射式火花点火機関

(57)【要約】
【課題】　燃料噴射弁の配設レイアウトの自由度を拡大でき、かつ、成層燃焼，均質燃焼の燃焼性の向上を図る。
【解決手段】　燃焼室４には空気を直接噴射する空気噴射弁７を配設して、吸気ポート，吸気弁を廃止しているので、燃料噴射弁６を最適な位置に配設することが可能で、しかも、吸気のタイミングを適切に設定できるため、成層燃焼はもとより均質燃焼の燃焼性を向上することができる。



１…シリンダブロック
２…ピストン
３…シリンダヘッド
４…燃焼室
５…点火プラグ
６…燃料噴射弁
７…空気噴射弁
９…空気通路
１０…キャビティ燃焼室
１２…排気ポート（排気通路）
１３…排気環流通路（不活性ガス供給通路）

1

【特許請求の範囲】

【請求項１】　吸気行程で燃焼室に空気を供給する空気供給手段と、燃焼室に直接燃料を噴射する燃料噴射弁と、点火プラグと、ピストン冠面にキャビティ燃焼室とを備え、低負荷域で圧縮行程中に燃料を噴射させて成層燃焼を行わせると共に、高負荷域で吸気行程中に燃料を噴射させて均質燃焼を行わせるようにした筒内噴射式火花点火機関において、前記空気供給手段を、燃焼室に直接空気を噴射する空気噴射弁で構成したことを特徴とする筒内噴射式火花点火機関。

【請求項２】　空気噴射弁を燃料噴射弁配置側に配設してこれらの取付角度を、噴射された燃料をキャビティ燃焼室へ輸送できる角度に設定したことを特徴とする請求項１に記載の筒内噴射式火花点火機関。

【請求項３】　空気噴射弁と燃料噴射弁の取付角度を、相互の噴射軸線が交差し、かつ、噴射方向が共にキャビティ燃焼室に指向する角度に設定したことを特徴とする請求項２に記載の筒内噴射式火花点火機関。

【請求項４】　空気噴射弁を複数個配設したことを特徴とする請求項２、３に記載の筒内噴射式火花点火機関。

【請求項５】　アイドリング時に１つの空気噴射弁から空気噴射を行わせて横向きの旋回流を形成させ、部分負荷および高負荷時に全空気噴射弁から空気噴射を行わせて縦向きの旋回流を形成させるようにしたことを特徴とする請求項４に記載の筒内噴射式火花点火機関。

【請求項６】　成層燃焼時における空気噴射弁の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期と、圧縮行程の前半で残りの空気量を噴射させる第２噴射時期とに多段に設定したことを特徴とする請求項１～５の何れかに記載の筒内噴射式火花点火機関。

【請求項７】　空気噴射弁を燃料噴射弁配置側に配設してこれらの取付角度を、噴射空気および噴射燃料がキャビティ燃焼室に指向し、かつ、噴射空気の噴射方向が噴射燃料の噴射方向よりも下向きとなって両噴射軸線が交差する角度に設定したことを特徴とする請求項１に記載の筒内噴射式火花点火機関。

【請求項８】　成層燃焼時における空気噴射弁の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期と、圧縮行程で燃料噴射直前に残りの空気量を噴射させる第２噴射時期とに多段に設定したことを特徴とする請求項７に記載の筒内噴射式火花点火機関。

【請求項９】　空気噴射弁を膨脹行程でも噴射作動させるようにしたことを特徴とする請求項１～８の何れかに記載の筒内噴射式火花点火機関。

【請求項１０】　空気噴射弁を排気行程でも噴射作動させるようにしたことを特徴とする請求項１～９の何れかに記載の筒内噴射式火花点火機関。

【請求項１１】　空気噴射弁の空気通路に、不活性ガス供給通路を接続して、所定量の不活性ガスを混合した空気を噴射させるようにしたことを特徴とする請求項１～１０の何れかに記載の筒内噴射式火花点火機関。

【請求項１２】　不活性ガス供給通路が、空気噴射弁の空気通路と機関排気通路とに跨って接続されて、排気ガスの一部を導入する排気還流通路であることを特徴とする請求項１１に記載の筒内噴射式火花点火機関。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は燃焼室に直接燃料を噴射する筒内噴射式火花点火機関に関する。

【０００２】

【従来の技術】筒内噴射式火花点火機関は、例えば特開平９－７９０７９号公報や特許第２５７７０１９号公報等に示されているように、シリンダヘッドに吸，排気ポートと、これら吸，排気ポートを開閉する吸，排気弁と、燃焼室のほぼ中心に臨む位置に設けた点火プラグと、噴射ノズルが燃焼室に臨む燃料噴射弁と、を配設して、低負荷域では圧縮行程の後期に燃料噴射弁より直接燃料を燃焼室に噴射して成層燃焼を行わせる一方、高負荷域では吸気行程中に前記燃料噴射を行わせて均質燃焼を行わせるようにしている。

【０００３】

【発明が解決しようとする課題】燃料噴射弁は排気弁配置側に配設すると既燃ガスの熱影響を大きく受けてしまい、また、燃焼室中心部に配設すると排気弁配置側に配設した場合と同様に熱影響を大きく受けてしまうことと、燃料噴射弁の中央設置により点火プラグ配設位置が燃焼室中央からずれて火炎伝播が良好に行われなくなってしまうことから、該燃料噴射弁は吸気弁配置側でしかも燃料と空気との混合性を考慮して吸気弁近傍位置に配設する必要があるため、該燃料噴射弁の配設位置が制約されてしまうばかりでなく、吸気ポート周りの構造によって取付角度にも制約を受けて成層燃焼および均質燃焼に最適な配設レイアウトを採ることが難しくなってしまう。

【０００４】これは、特に吸，排気弁が多弁化したエンジンコンセプトでは益々顕著となってしまう。

【０００５】また、このような燃料噴射弁の配設上の問題とは別に、吸気弁の開閉制御によって吸気ポートから吸気を行わせるため、ポンプ損失や動弁系のフリクション損失によるＣＶ値の低下は否めず、特に、筒内噴射式火花点火機関では成層燃焼時に圧縮行程中に噴射された燃料を燃焼室中央の点火プラグ周りに確実に輸送させることが肝要で、このため、吸気ポートには横方向旋回流（スワール）や縦方向旋回流（タンブル流）を生成させるための可変要素を付加する必要があるため、前述のポンプ損失やフリクション損失は更に増大してしまう。

【０００６】更に、成層燃焼時には前述のように圧縮行程で噴射された燃料を新気の旋回流に乗せて点火プラグ

周りに輸送させるのであるが、吸気行程で吸気ポートから吸入される新気は吸気ポートの旋回付与手段により旋回流が形成されても、この旋回流は燃料噴射時期には減衰されて、この減衰された旋回流に対して燃料を噴射して燃料の輸送と燃焼を行わせなければならないため、吸気制御と燃料噴射制御のマッチングが難しく、しかも、ガス流動が弱まるために成層燃焼の向上は大きく期待することはできない。

【０００７】そこで、本発明は燃料噴射弁の配設レイアウトの自由度を拡大できると共に、吸気タイミングを適切に設定でき、かつ、強いガス流動を生成させることができて成層燃焼はもとより均質燃焼の燃焼性を一段と向上することができる筒内噴射式火花点火機関を提供するものである。

【０００８】

【課題を解決するための手段】請求項１の発明にあっては、吸気行程で燃焼室に空気を供給する空気供給手段と、燃焼室に直接燃料を噴射する燃料噴射弁と、点火プラグと、ピストン冠面にキャビティ燃焼室とを備え、低負荷域で圧縮行程中に燃料を噴射させて成層燃焼を行わせると共に、高負荷域で吸気行程中に燃料を噴射させて均質燃焼を行わせるようにした筒内噴射式火花点火機関において、前記空気供給手段を、燃焼室に直接空気を噴射する空気噴射弁で構成したことを特徴としている。

【０００９】請求項２の発明にあっては、請求項１に記載の空気噴射弁を燃料噴射弁配置側に配設してこれらの取付角度を、噴射された燃料をキャビティ燃焼室へ輸送できる角度に設定したことを特徴としている。

【００１０】請求項３の発明にあっては、請求項２に記載の空気噴射弁と燃料噴射弁の取付角度を、相互の噴射軸線が交差し、かつ、噴射方向が共にキャビティ燃焼室に指向する角度に設定したことを特徴としている。

【００１１】請求項４の発明にあっては、請求項２および３に記載の空気噴射弁を複数個配設したことを特徴としている。

【００１２】請求項５の発明にあっては、請求項４に記載の空気噴射弁は、アイドリング時に１つの空気噴射弁から空気噴射を行わせて横向きの旋回流を形成させ、部分負荷および高負荷時に全空気噴射弁から空気噴射を行わせて縦向きの旋回流を形成させるようにしたことを特徴としている。

【００１３】請求項６の発明にあっては、請求項１～５に記載の成層燃焼時における空気噴射弁の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期と、圧縮行程の前半で残りの空気量を噴射させる第２噴射時期とに多段に設定したことを特徴としている。

【００１４】請求項７の発明にあっては、請求項１に記載の空気噴射弁を燃料噴射弁配置側に配設してこれらの取付角度を、噴射空気および噴射燃料がキャビティ燃焼室に指向し、かつ、噴射空気の噴射方向が噴射燃料の噴射方向よりも下向きとなって両噴射軸線が交差する角度に設定したことを特徴としている。

【００１５】請求項８の発明にあっては、請求項７に記載の成層燃焼時における空気噴射弁の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期と、圧縮行程で燃料噴射直前に残りの空気量を噴射させる第２噴射時期とに多段に設定したことを特徴としている。

【００１６】請求項９の発明にあっては、請求項１～８に記載の空気噴射弁を、膨張行程でも噴射作動させるようにしたことを特徴としている。

【００１７】請求項１０の発明にあっては、請求項１～９に記載の空気噴射弁を排気行程でも噴射作動させるようにしたことを特徴としている。

【００１８】請求項１１の発明にあっては、請求項１～１０に記載の空気噴射弁の空気通路に、不活性ガス供給通路を接続して、所定量の不活性ガスを混合した空気を噴射させるようにしたことを特徴としている。

【００１９】請求項１２の発明にあっては、請求項１１に記載の不活性ガス供給通路が、空気噴射弁の空気通路と機関排気通路とに跨って接続されて、排気ガスの一部を導入する排気還流通路であることを特徴としている。

【００２０】

【発明の効果】請求項１に記載の発明によれば、空気供給手段を燃焼室に直接空気を噴射する空気噴射弁で構成して、吸気ポートおよび吸気弁を廃止しているため、燃料噴射弁をこれら吸気ポート，吸気弁に制約されることなく最適な燃料噴射方向が得られる位置および角度に取付けることができる。

【００２１】また、吸気弁およびその動弁系のフリクション損失がなく、しかも吸気弁，吸気ポートの通気抵抗によるポンプ損失がなくなることと併せて、吸気行程で噴射した高圧の空気がピストンの押し下げ方向に作用するためポンプ損失の低減効果が大きく、ＣＶ値を高めることができる。

【００２２】更に、高圧の空気噴射によって強いガス流動を形成できるため旋回流付与手段を用いることなく成層燃焼時の点火プラグ周りへの燃料輸送を良好に行わせることができると共に、燃料と空気との干渉を意図的に設定できて燃料の微粒化や成層化を容易に行え、従って、成層燃焼および均質燃焼の燃焼性を向上することができる。

【００２３】また、燃料の吸気行程噴射を行わせるのに際して、燃料噴射弁から噴射された燃料と吸気弁との干渉に留意する必要がないため、燃料噴霧角度を最適に設定することができるから、均質燃焼はもとより成層燃焼の燃焼性をより一層向上することができる。

【００２４】請求項２に記載の発明によれば、請求項１の発明の効果に加えて、空気噴射弁を吸気ポート，吸気

弁による制約を受けることなく、成層燃焼時に噴射された燃料をキャビティ燃焼室へ輸送できる最適な角度に設定してあるから、ガス流動の保存性が高く燃料の点火プラグ周りへの輸送性を向上できて成層燃焼の燃焼性を更に向上することができる。

【００２５】請求項３に記載の発明によれば、請求項２の発明の効果に加えて、空気噴射軸線と燃料噴射軸線とが交差しているため、燃料の吸気行程噴射時に燃料の微粒化を行えると共に、噴射空気より気化潜熱を奪って空気温度を下げられるため、実充填効率を高められて高出力が要求される均質燃焼を行う高負荷域での出力の向上を実現することができ、しかも、噴射空気がキャビティ燃焼室に指向するため、キャビティ燃焼室に燃料が付着するのを抑制できてスモーク発生および未燃ＨＣの発生を低下させることができる。

【００２６】請求項４に記載の発明によれば、請求項２および３の発明の効果に加えて、空気噴射弁を複数個配設してあるため、１つの空気噴射弁では空気供給量が不十分な場合や、過給のようにより多くの空気が必要とする場合に適切に対応することができる。

【００２７】請求項５に記載の発明によれば、請求項４の発明の効果に加えて、アイドリング時には１つの空気噴射弁から空気噴射を行わせて横向きの旋回流（スワール）を形成させるため、供給空気量の少ないアイドリング時でもキャビティ燃焼室に確実にスワールを形成できて燃焼の安定化を図ることができ、他方、部分負荷および高負荷時には全空気噴射弁から空気噴射を行わせて縦向きの旋回流（タンブル流，逆タンブル流）を形成させるため、キャビティ燃焼室への燃料付着を抑制してスモーク，未燃ＨＣの発生を低減でき、均質燃焼，成層燃焼の安定化と出力の向上とを実現することができる。

【００２８】請求項６に記載の発明によれば、請求項１～５の発明の効果に加えて、成層燃焼時には圧縮行程の前半でも空気噴射を行わせるため、ガス流動を強化して点火プラグ周りへの燃料の輸送性を高められ、成層燃焼をより一層安定化することができる。

【００２９】請求項７に記載の発明によれば、請求項１の発明の効果に加えて、噴射空気および噴射燃料が共にキャビティ燃焼室に指向し、かつ、噴射空気が噴射燃料よりも下向きに噴射されるため、成層燃焼時はキャビティ燃焼室に空気の膜を早い流れとして形成できて、その上に燃料を噴射させるためにキャビティ燃焼室への燃料付着を回避して成層燃焼の安定化と、スモーク，未燃ＨＣの低減化とを図ることができる。

【００３０】また、均質燃焼時には噴射空気と噴射燃料との混合，撹拌を積極的に行えると共に燃料の微粒化を行えるから均質燃焼の安定化を図ることができ、しかも、キャビティ燃焼室に高圧の噴射空気が吹き当るため、該キャビティ燃焼室への燃料付着を回避できてスモーク，未燃ＨＣの低減化を図ることができる。

【００３１】請求項８に記載の発明によれば、請求項７の発明の効果に加えて、成層燃焼時には圧縮行程で燃料噴射の直前にも空気噴射を行わせるため、キャビティ燃焼室に形成される空気の膜を強化して燃料付着をより確実に防止できると共に、ガス流動を強化できて点火プラグ周りへの燃料の輸送性を高めることができる。

【００３２】請求項９に記載の発明によれば、請求項１～８の発明の効果に加えて、膨脹行程でも空気噴射弁からの空気噴射を行わせるため、未燃ＨＣの燃焼を活性化させて熱効率を向上できると共にスモーク，未燃ＨＣの低減化対策を徹底することができる。

【００３３】請求項１０に記載の発明によれば、請求項１～９の発明の効果に加えて、排気行程でも空気噴射弁からの空気噴射を行わせるため掃気効率を高めることができる。

【００３４】請求項１１に記載の発明によれば、請求項１～１０の発明の効果に加えて、空気噴射弁からは不活性ガスを混合した空気を噴射させるためＮＯ，の低減効果を得ることができる。

【００３５】請求項１２に記載の発明によれば、請求項１１の発明の効果に加えて、不活性ガスとして既燃ガスを有効利用するため、排気還流によってコスト的に有利にＮＯ，低減効果を得ることができる。

【００３６】

【発明の実施の形態】以下、本発明の実施形態を図面と共に詳述する。

【００３７】図１，２において、１はシリンダブロック、２はピストン、３はシリンダヘッド、４はこれらシリンダブロック１，ピストン２およびシリンダヘッド３で形成された燃焼室を示す。

【００３８】シリンダヘッド３には燃焼室４のほぼ中央に臨む位置に点火プラグ５を配設してあると共に、図外の排気弁の配置側と反対側の側部に、燃料を直接燃焼室４に噴射する燃料噴射弁６を配設してある。

【００３９】このシリンダヘッド３には通常のエンジンとは異なって吸気ポートおよび吸気弁はなく、前記燃料噴射弁６の配置側に、高圧ポンプ８で圧縮されて空気通路９により送られてくる高圧の空気を直接燃焼室４に噴射する空気噴射弁７を配設してある。

【００４０】ピストン２の冠面には前記燃料噴射弁６を配設した側に偏寄した略半部に、成層燃焼時に圧縮行程中に燃料噴射弁６から噴射された燃料を受容するキャビティ燃焼室１０を形成してある。

【００４１】燃料噴射弁６は、成層燃焼時に圧縮行程中に燃料を噴射した際に、この噴射燃料がキャビティ燃焼室４に指向して該キャビティ燃焼室４に確実に受容される角度で取付けてある一方、空気噴射弁７は吸気行程で噴射された空気が例えば図２に矢印で示すように右旋回して横向きの旋回流（スワール）が形成され、圧縮行程でこのスワールがキャビティ燃焼室１０内に保存されて

該圧縮行程中に噴射された燃料を点火プラグ５周りへ確実に輸送し得る角度で取付けてある。

【００４２】図３は４サイクル行程における成層燃焼時の空気噴射弁７，燃料噴射弁６の各噴射時期と点火プラグ５の点火時期とを示し、また、図４は均質燃焼時のこれら空気噴射弁７，燃料噴射弁６の各噴射時期と点火プラグ５の点火時期とを示しており、Ａは空気の噴射時期を、Ｆは燃料の噴射時期を、Ｓは点火時期をそれぞれ示している。

【００４３】従って、この第１実施形態の構成によれば、吸気行程で燃焼室４に空気を供給する空気供給手段を、該燃焼室４に直接高圧の空気を供給する空気噴射弁７で構成して、吸気ポートおよび吸気弁を廃止しているため、燃料噴射弁６をこれら吸気ポートや吸気弁に制約を受けることなく最適な燃料噴射方向が得られる位置および角度に取付けることができる。

【００４４】また、吸気弁およびその動弁系のフリクション損失がなく、しかも吸気弁，吸気ポートの通気抵抗によるポンプ損失がなくなることと併せて、吸気行程で噴射した高圧の空気がピストン２の押し下げ方向に作用するためポンプ損失の低減効果が大きく、ＣＶ値を高めることができる。

【００４５】更に、高圧の空気噴射によって強いガス流動を形成でき、かつ、空気噴射弁７を吸気ポートや吸気弁による制約を受けずにスワールを形成できる最適な角度で取付けることができるため、旋回流付与手段を用いることなくガス流動の保存性を高めることができ、従って、成層燃焼時に点火プラグ５周りへの燃料の輸送性を高められ、また、空気噴射弁７と燃料噴射弁６との取付角度は燃料と空気との干渉を意図的に設定することもできて燃料の微粒化や成層化を容易に行うことができるから、成層燃焼および均質燃焼の燃焼性を向上することができる。

【００４６】また、燃料の吸気行程噴射を行わせるのに際して、燃料噴射弁６から噴射された燃料と吸気弁との干渉に留意する必要がないため、燃料噴霧角度を最適に設定することができるから、均質燃焼はもとより成層燃焼の燃焼性をより一層向上することができる。

【００４７】図５は本発明の第２実施形態を示すもので、この実施形態にあっては前記図１，２に示した第１実施形態の構成において、成層燃焼時における前述の空気噴射弁７の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期A_1と、圧縮行程の前半で残りの空気量を噴射させる第２噴射時期A_2とに多段に設定してある。

【００４８】従って、この第２実施形態の構成によれば、前記第１実施形態の効果に加えて、成層燃焼時には圧縮行程の前半でも空気噴射を行わせるため、スワールを強化して点火プラグ５周りへの燃料の輸送性を高めることができて、成層燃焼をより一層安定化させることができる。

【００４９】図６，７は本発明の第３実施形態を示すもので、この実施形態にあっては成層燃焼時（図６）および均質燃焼時（図７）の何れの運転状態時にも、膨脹行程で空気噴射弁７を噴射作動させて所要量の追加空気の噴射$A_{\alpha 1}$を行わせるようにしている。

【００５０】従って、この第３実施形態の構成によれば、前記第１実施形態および第２実施形態の効果に加えて、膨脹行程でも燃焼温度の高い温度条件下で空気噴射弁７によって所要量の空気噴射$A_{\alpha 1}$を行わせるため、この追加空気によって未燃ＨＣの燃焼を活性化させて熱効率を向上できると共にスモークおよび未燃ＨＣの低減化対策を徹底することができる。

【００５１】前記第３実施形態では追加空気の噴射を膨脹行程で行わせているが、図８，９に示す第４実施形態のように排気行程でも追加空気の噴射$A_{\alpha 2}$を行わせれば、掃気効率を高めることができる。

【００５２】また、この排気行程での追加空気の噴射$A_{\alpha 2}$を、鎖線で示すように高い燃焼温度が維持される排気行程の前半で行わせれば、膨脹行程で追加空気の噴射$A_{\alpha 1}$を行った場合と同様に未燃ＨＣの燃焼の活性化を期待することができ、特に該排気行程ではピストンの上昇によって掻き落されるシリンダライナの付着未燃ＨＣの燃焼活性化を図ることもできる。

【００５３】図１０，１１は本発明の第５実施形態を示すもので、この実施形態にあっては空気噴射弁７と燃料噴射弁６の取付角度を、両噴射軸線が上下方向および水平方向で交差し、かつ、噴射方向が共にキャビティ燃焼室１０に指向する角度に設定してある。

【００５４】従って、この第５実施形態の構成によれば、前記第１実施形態と同様の効果が得られる他、空気噴射軸線と燃料噴射軸線とが交差しているため、燃料の吸気行程噴射時に燃料の微粒化を行えると共に、噴射空気より気化潜熱を奪って空気温度を下げられるため、実充填効率を高められて高出力が要求される均質燃焼を行う高負荷域での出力の向上を実現することができる。

【００５５】しかも、噴射空気がキャビティ燃焼室１０に指向するため、キャビティ燃焼室１０に燃料が付着するのを抑制できてスモークおよび未燃ＨＣの発生を低下させることができる。

【００５６】ここで、この第５実施形態において、空気噴射弁７の成層燃焼時における噴射時期を図５に示した第２実施形態と同様に、吸気行程における第１噴射時期A_1と、圧縮行程前半における第２噴射時期A_2とに多段に設定すれば、該第２噴射時期A_2でキャビティ燃焼室１０に噴射された空気は該キャビティ燃焼室１０で十分にイナーシャーを持ったスワールとなって点火プラグ５周りにより確実に燃料を輸送することが可能となり、成層燃焼の安定性を更に高めることができる。

【００５７】また、燃料の早噴き・遅点火を実現するこ

ともできるから、混合気形成が良好でかつＮＯｘ低減効果が得られ、しかも、燃焼の熱発生時期が遅れるため熱効率を高めることもできる。

【００５８】図１２，１３は本発明の第６実施形態を示すもので、この実施形態にあっては空気噴射弁７を複数個、具体的には２つの空気噴射弁７，７を燃料噴射弁６の配置側で、平面視して該燃料噴射弁６の噴射軸線を中心に内向きにほぼ線対称に取付けてある。

【００５９】また、これら２つの空気噴射弁７，７は噴射空気が図１２の矢印で示すように、点火プラグ５の下側を通って図外の排気弁側からピストン２の冠面に向って流れる、所謂順タンブルの縦向き旋回流を形成し得る取付角度で配設してある。

【００６０】従って、この第６実施形態の構成によれば、前記第１実施形態と同様の効果が得られる他、２つの空気噴射弁７，７を配設してあるため１つの空気噴射弁７では空気供給量が不十分な場合や、過給のようにより多くの空気が必要とする場合に適切に対応することができる。

【００６１】また、アイドリング時には１つの空気噴射弁７からのみ空気噴射を行わせてスワールを形成させ、部分負荷および高負荷時には両空気噴射弁７，７から同時に空気噴射を行わせて順タンブル流を形成させるようにすれば、供給空気量の少ないアイドリング時でもキャビティ燃焼室１０に確実にスワールを形成できて燃焼の安定化を図ることができ、他方、部分負荷および高負荷時には順タンブル流によってキャビティ燃焼室１０への燃料付着を抑制してスモーク，未燃ＨＣの発生を低減できるため、均質燃焼，成層燃焼の安定化と出力の向上とを実現することができる。

【００６２】更に、この第６実施形態の場合も図５に示した第２実施形態と同様に、成層燃焼時における２つの空気噴射弁７，７の噴射時期を吸気行程における第１噴射時期A_1と、圧縮行程前半における第２噴射時期A_2とに多段に設定することによって、順タンブル流を強化でき点火プラグ５周りへの燃料の輸送性を高めることができる。

【００６３】なお、この実施形態では順タンブル流を形成させるようにしているが、逆タンブル流を形成できるように空気噴射弁７，７の取付角度を縦向きにすることも可能である。

【００６４】図１４，１５は本発明の第７実施形態を示すもので、この実施形態にあっては空気噴射弁７を燃料噴射弁６のほぼ直上位置に配置し、これら空気噴射弁７，燃料噴射弁６の取付角度を、噴射空気および噴射燃料がキャビティ燃焼室１０に指向し、かつ、噴射空気の噴射方向が噴射燃料の噴射方向よりも下向きとなって相互の噴射軸線が上下方向に交差する角度に設定し、噴射空気が図１４の矢印で示すように燃料噴射弁６の前端部分を横切ってキャビティ燃焼室１０に向かい、該キャビティ燃焼室１０で反転して点火プラグ５に向って流れる、所謂逆タンブル流が形成されるようにしてある。

【００６５】従って、この第７実施形態の構成によれば、前記第１実施形態と同様の効果が得られる他、噴射空気および噴射燃料が共にキャビティ燃焼室１０に指向し、かつ、噴射空気が噴射燃料よりも下向きに噴射されて逆タンブル流が形成されるため、成層燃焼時はキャビティ燃焼室１０に空気の膜を早い流れとして形成できて、その上に燃料を噴射させるためにキャビティ燃焼室１０への燃料付着を回避して成層燃焼の安定化と、スモーク，未燃ＨＣの低減化とを図ることができる。

【００６６】また、均質燃焼時には噴射空気と噴射燃料との混合，攪拌を積極的に行えると共に燃料の微粒化を行えるから均質燃焼の安定化を図ることができ、しかも、キャビティ燃焼室１０に高圧の噴射空気が吹き当るため、該キャビティ燃焼室１０への燃料付着を回避できてスモーク，未燃ＨＣの低減化を図ることができる。

【００６７】更に、前記図１０，１１に示した第５実施形態と同様にこの燃料の吸気行程噴射を行う均質燃焼時に、噴射燃料が噴射空気より気化潜熱を奪って空気温度を下げられるため、実充填効率を高められて高出力を得ることができる。

【００６８】図１６は本発明の第８実施形態を示すもので、この実施形態にあっては前記図１４，１５に示した第７実施形態の構造において、成層燃焼時における前述の空気噴射弁７の噴射時期を、吸気行程で所定の供給空気量のうち一部を残して噴射させる第１噴射時期A_1と、圧縮行程後期の燃料噴射時期Ｆの直前に残りの空気量を噴射させる第２噴射時期に設定してある。

【００６９】従って、この第８実施形態の構成によれば成層燃焼時には圧縮行程で燃料噴射の直前にも空気噴射を行わせるため、キャビティ燃焼室１０に形成される空気の膜を強化して燃料付着をより確実に防止できるとともに、逆タンブル流を強化でき点火プラグ５周りへの燃料の輸送性を高めることができる。

【００７０】なお、図１０～１６に示した各実施形態において、図６，７，又は図８，９に示した実施形態と同様に膨脹行程、および又は排気行程でも空気噴射弁７を噴射作動させて追加の空気を噴射させることによって、未燃ＨＣの低減効果と掃気効率の向上とを図ることができる。

【００７１】図１７は本発明の第９実施形態を示すもので、この実施形態ではＮＯｘ低減対策のため、空気噴射弁７から不活性ガスを混合した空気を燃焼室４に噴射供給するようにしてある。

【００７２】図１７では便宜的に図１に示した第１実施形態のエンジンコンセプトに適用した場合を示しており、本実施形態では空気噴射弁７の空気通路９の途中にミキサ室１１を設け、該ミキサ室１１と排気ポート１２とに跨って排気還流通路１３を接続し、該排気還流通路

１３に介装した排気還流制御弁装置１４による制御の下に不活性ガスとして吸気量に応じた適正量の還流排気（ＥＧＲ）を行って、ミキサ室１１で新気と混合させて外部ＥＧＲを行わせ、ＮＯ，の低減効果を得るようにしている。なお、図１７中、１５は排気弁を示す。

【図面の簡単な説明】

【図１】本発明の第１実施形態の構成を概略的に示す断面説明図。

【図２】本発明の第１実施形態の概略的平面説明図。

【図３】本発明の第１実施形態の成層燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図４】本発明の第１実施形態の均質燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図５】本発明の第２実施形態の成層燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図６】本発明の第３実施形態の成層燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図７】本発明の第３実施形態の均質燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図８】本発明の第４実施形態の成層燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図９】本発明の第４実施形態の均質燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図１０】本発明の第５実施形態の構成を概略的に示す断面説明図。

【図１１】本発明の第５実施形態の概略的平面説明図。

【図１２】本発明の第６実施形態の構成を概略的に示す断面説明図。

【図１３】本発明の第６実施形態の概略的平面説明図。

【図１４】本発明の第７実施形態の構成を概略的に示す断面説明図。

【図１５】本発明の第７実施形態の概略的平面説明図。

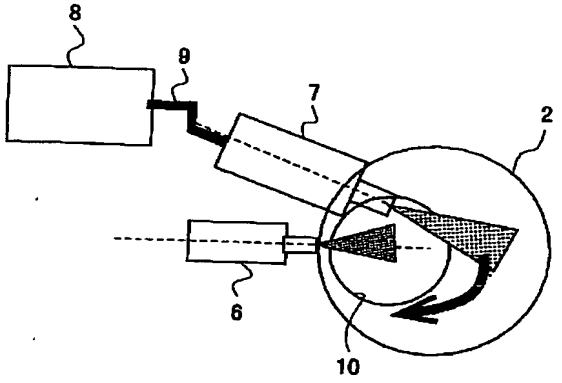
【図１６】本発明の第８実施形態の成層燃焼時における空気噴射時期，燃料噴射時期および点火時期を示す説明図。

【図１７】本発明の第９実施形態の構成を概略的に示す断面説明図。

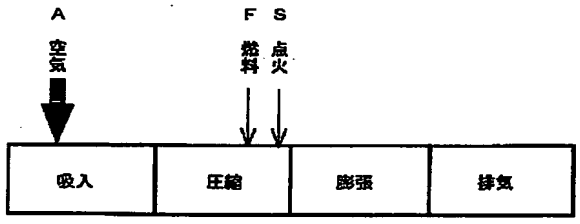
【符号の説明】

１　シリンダブロック
２　ピストン
３　シリンダヘッド
４　燃焼室
５　点火プラグ
６　燃料噴射弁
７　空気噴射弁
９　空気通路
１０　キャビティ燃焼室
１２　排気ポート（排気通路）
１３　排気還流通路（不活性ガス供給通路）

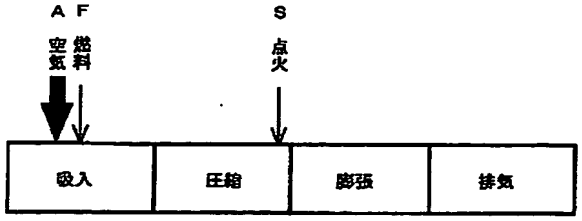
【図２】



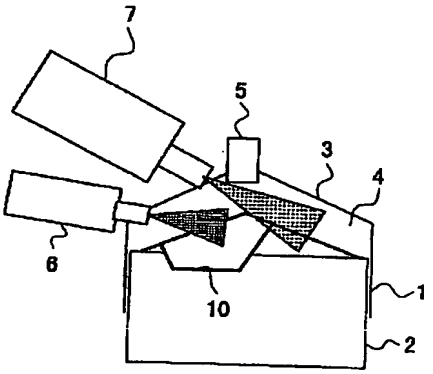
【図３】



【図４】

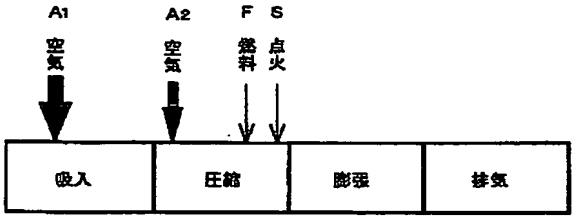


【図１】

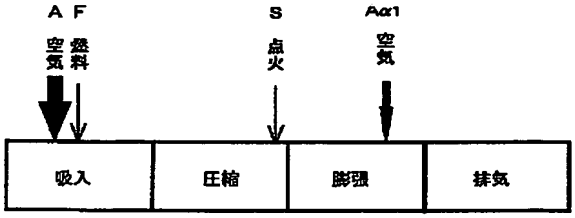


１…シリンダブロック
２…ピストン
３…シリンダヘッド
４…燃焼室
５…点火プラグ
６…燃料噴射弁
７…空気噴射弁
９…空気通路
１０…キャビティ燃焼室
１２…排気ポート（排気通路）
１３…排気環流通路（不活性ガス供給通路）

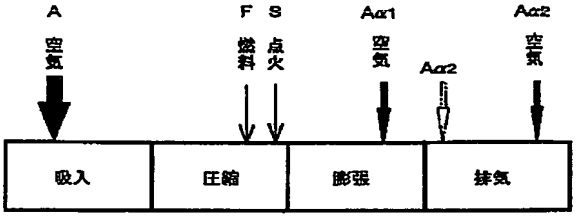
【図５】



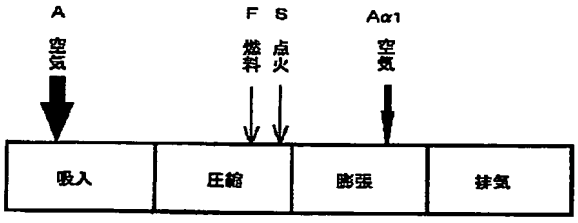
【図７】



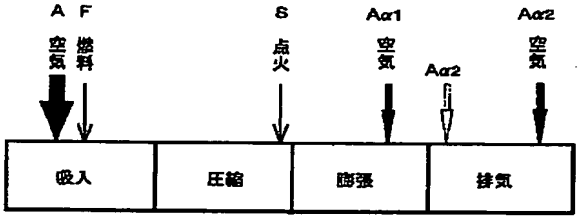
【図８】



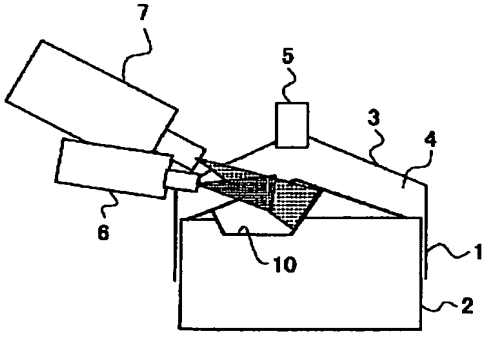
【図６】



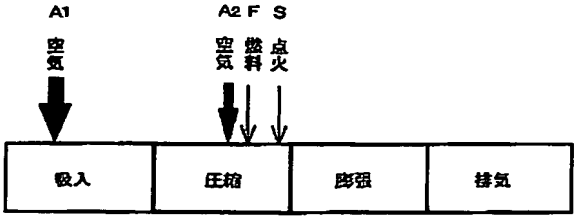
【図９】



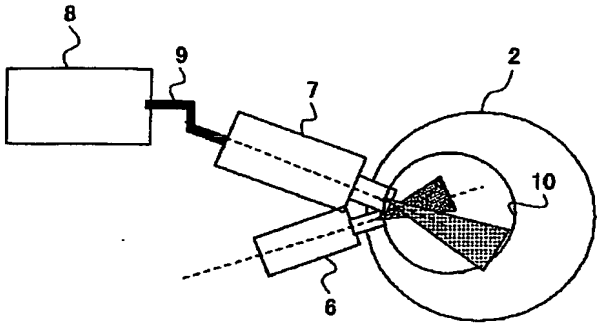
【図１０】



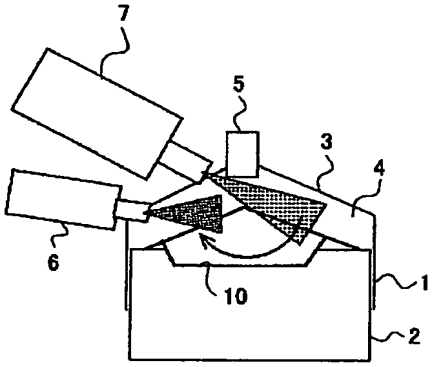
【図１６】



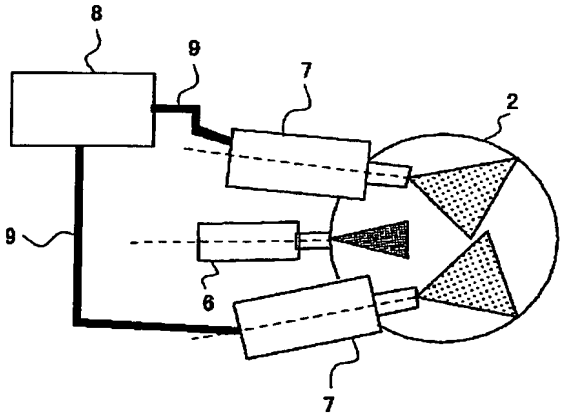
【図１１】



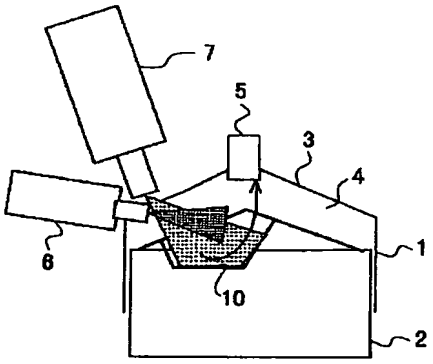
【図１２】



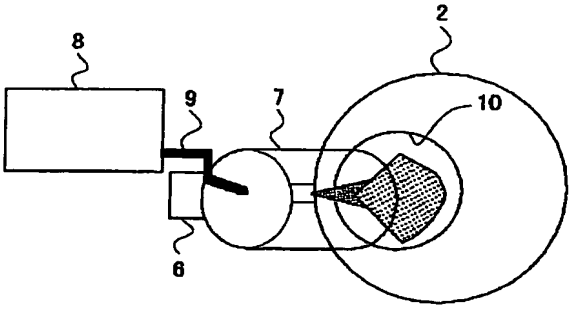
【図１３】



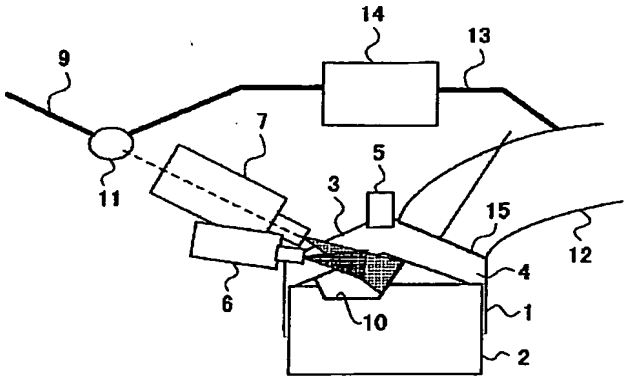
【図１４】



【図１５】



【図１７】



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			325G	

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